2.7. DATA INTEGRATION (GLOBALVIEW)

The Cooperative Atmospheric Data Integration Project for carbon dioxide, established in 1995, continues its effort to improve the temporal and spatial coverage of atmospheric CO_2 observations by integrating existing observations made by different laboratories into a cooperative global network. Twenty laboratories in 13 countries now participate in this activity, contributing their up-to-date, high-precision CO_2 records from land-surface, aircraft, ship, and tower sites (see http://www.cmdl.noaa.gov/ccgg/globalview/co2). Data from this cooperative network are used to derive GLOBALVIEW-CO_2, a globally consistent data product for use with carbon cycle modeling studies [GLOBALVIEW-CO_2, 2001]. GLOBALVIEW-CO_2, which is updated annually, contains no actual data. The product consists of smoothed time series derived directly from observations as well as statistical summaries of atmospheric variability, and average diurnal and seasonal patterns. Since it was first introduced in 1996, more than 2500 Internet requests (~37 per month) for the data product have been made from more than 50 countries. Interest in GLOBALVIEW-CO_2 continues to increase (Figure 2.23). In 1997 the average number of accesses per month was 14. In 2000 the average increased to 53 per month, and in 2001 it increased again to more than 70 inquiries per month.

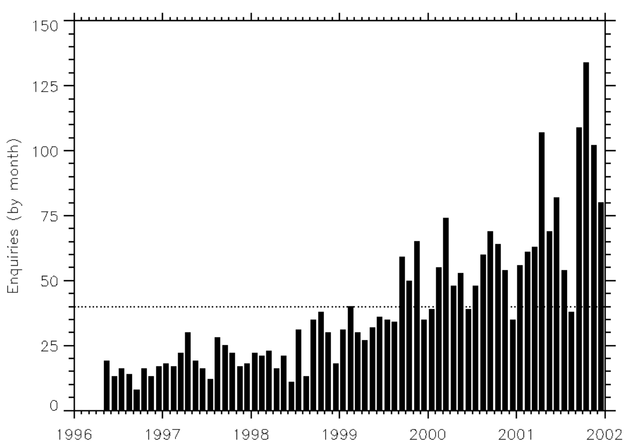

Fig. 2.23. Number of Internet requests for the GLOBALVIEW-CO_2 data product. The dotted line is the overall average since 1996.

Assessing the level of comparability among actual observations made by different laboratories continues to be a primary focus of this activity. The challenge is to ensure that spatial and temporal patterns among observations from the cooperative global network are due to CO_2 sources and sinks as affected by atmospheric mixing and transport and not due to inconsistencies among internal calibration scales and potential systematic errors introduced when sampling the atmosphere. The level of traceability of each laboratory's internal CO_2 calibration scale to the absolute WMO CO_2 mole fraction scale must be determined to properly assess comparability. Periodic cylinder-air ("round-robin") intercomparison experiments endorsed by the WMO and International Atomic Energy Agency (IAEA) are used to make this assessment. Participating laboratories compare their measurements of CO_2 and other trace species and isotopes in dry air made on a set of circulating high-pressure cylinders. These experiments are critical for the assessment of each laboratory's ability to make high-precision measurements and maintain their internal calibration scales. Results from the 1995/1996 cylinder-air comparison suggest that measurements made by laboratories contributing to GLOBALVIEW-CO_2 are comparable to within 0.2 µmol mol^{-1} with respect to calibration [*Peterson et al.*, 1999]. Preliminary results from the most recent round-robin experiment (1999/2000) suggest a slight improvement in the number of laboratories with agreement at the 0.1 µmol mol^{-1} level. Current scientific objectives require a global network precision of 0.1 µmol mol^{-1} among northern hemisphere observations and 0.05 µmol mol^{-1} among southern hemisphere observations [*WMO*, 1981]. Attaining this level of comparability among atmospheric observations with existing technology requires laboratories to maintain a level of traceability to the WMO scale significantly better than 0.05 µmol mol^{-1}. Although the cylinder-air results suggest there is considerable work yet to be done, it has been demonstrated that this level of agreement is attainable.

Results from three WMO-endorsed cylinder-air round-robin intercomparisons (1991/1993, 1995/1997, and 1998/2000) suggest that the Meteorological Service of Canada (MSC) has maintained traceability of its internal calibration scale to the WMO CO_2 mole fraction scale to within 0.03 µmol mol^{-1}. However, it cannot be concluded, based on these results alone, that atmospheric measurements made by MSC and NOAA (which maintains the WMO CO_2 scale) are comparable to this same level of agreement. Additional errors may be introduced into measurements of atmospheric air when ambient samples are collected, dried, stored, extracted, and analyzed. Cylinder-air comparisons are expressly designed to exclude these potential sources of error. To complement the periodic cylinder-air comparisons, laboratories are establishing ongoing flask-air intercomparison (ICP) experiments whereby laboratories can more directly compare atmospheric measurements. CCGG has ongoing ICP activities with the Commonwealth Scientific and Industrial Research Organization (CSIRO, Australia); MSC (Canada); National Institute for Water and Atmospheric Research (NIWA, New Zealand); and CMDL Halocarbons and other Atmospheric Trace Species group (HATS).

The effectiveness of a flask-air ICP experiment depends on several essential features. First, participants must view the ICP activity as an additional level of quality control whereby measurements are routinely scrutinized. Potential problems identified by a collaborating laboratory should not be viewed as an embarrassment but as proof that the ICP is working effectively. Second, the ICP activity is an ongoing long-term program of routine (at least weekly) comparisons of atmospheric samples. Third, the ICP experiment must include supporting measurements (e.g., control samples) that can be used to narrow possible causes when differences are observed. Fourth, the ICP activity should have minimal impact on daily operations. This is accomplished only if participating laboratories have advanced data management tools in place. Analysis of ICP samples and processing and data exchange between laboratories must be automatic and routine. Finally, ICP results must be summarized automatically and made readily available to participants. Timely feedback improves the likelihood that potential problems are detected early (Figure 2.24).

At this time, only the ICP experiments with CSIRO and MSC include the essential features described above and are proving to be valuable tools to monitor measurement quality and assess comparability. The MSC-NOAA flask-air ICP experiment, begun in late 1999, is modeled after the long-time CSIRO-NOAA experiment [*Masarie et al.*, 2001] whereby both laboratories routinely analyze the same atmospheric air sample. MSC and NOAA independently collect samples of air weekly at Alert, Nunavut, Canada, using their respective flasks and sample collection strategies. Station personnel collect at approximately the same time one pair of MSC flasks and two pairs of NOAA flasks. All flasks are shipped to MSC in Downsview, Ontario, where one of the two NOAA flask pairs is first analyzed by the Carbon Cycle Research Laboratory (CCRL) at MSC for CO_2, CH_4, CO, N_2O, and SF_6 before being shipped to Boulder and analyzed a second time by CCGG for the same suite of trace gases.

Figure 2.25 shows CO_2 measurement differences (MSC minus NOAA) from analysis of the same air in flask

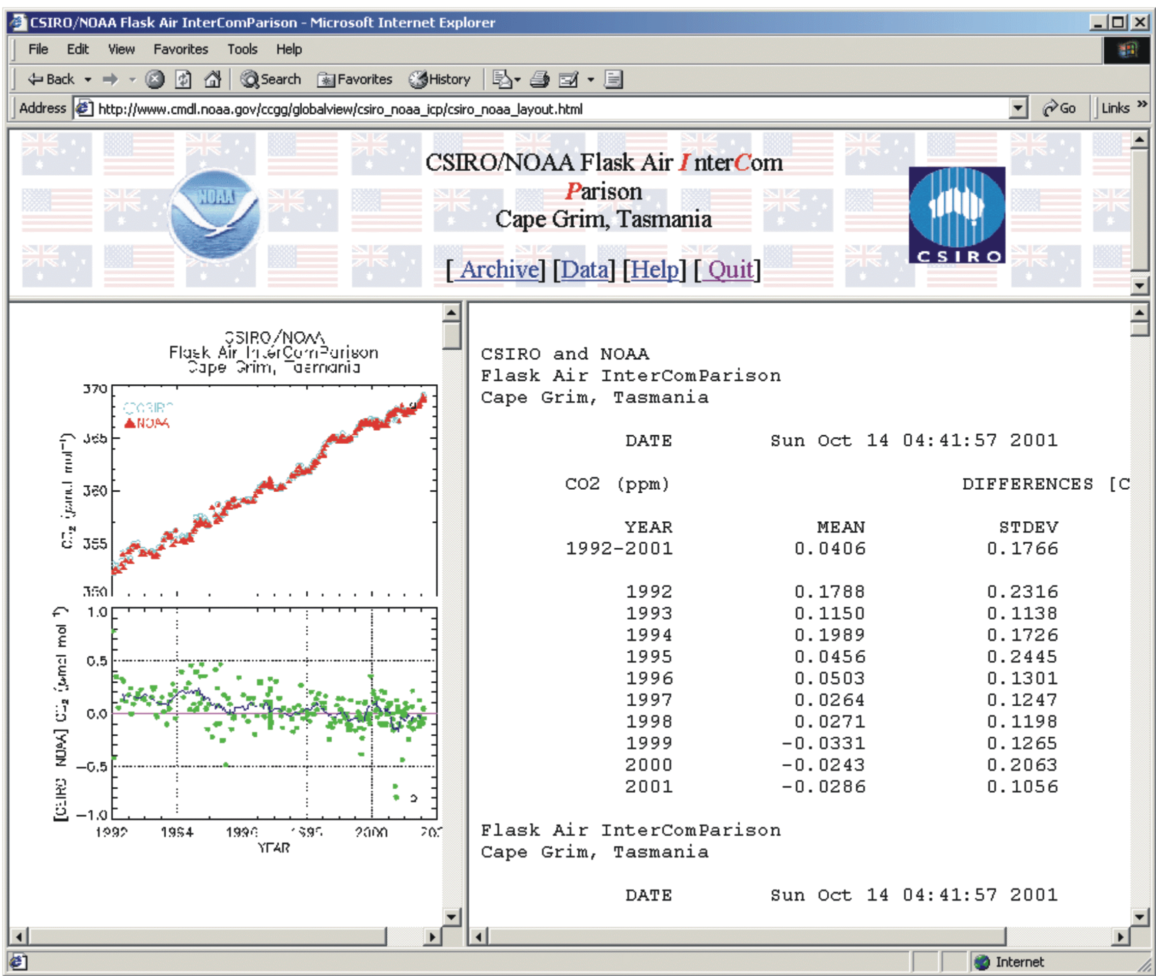

Fig. 2.24. Up-to-date flask-air intercomparison results available to participating laboratories with restricted WWW page access.

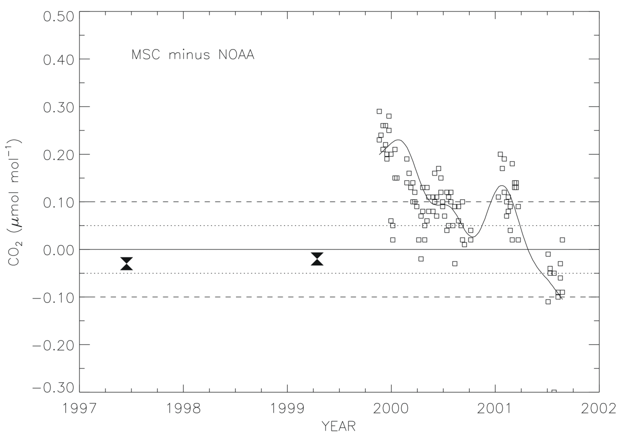

Fig. 2.25. Differences (MSC minus NOAA) between independent measurements of the same air in flask samples collected at Alert, Nunavut, Canada (open squares). Also plotted is a smooth curve fitted to the differences between individual measurements. The mean differences (MSC minus NOAA) determined from multiple intercomparisons of air in high-pressure cylinders are shown as solid hourglass symbols. The dotted and dashed lines about the zero difference line identify ±0.05 and ±0.1 µmol mol^{-1} target levels.

samples collected at Alert. The average difference is 0.10 ± 0.14 µmol mol^{-1} (n = 104). High-frequency (4-6 wk) noise in the differences is small and enables us to better pinpoint when systematic changes in the distribution occur than in the CSIRO-CMDL comparison. This information is used by MSC and NOAA to re-examine experimental changes that may have inadvertently introduced errors, i.e., errors that went undetected by conventional internal quality assurance procedures (see section 2.2.2). Results from the cylinder-air round-robin experiments are also shown in Figure 2.25 and clearly demonstrate that the maintenance of direct traceability to the WMO CO_2 mole fraction scale does not guarantee comparability among atmospheric observations. Note that, without first establishing traceability, exclusion of calibration as a possible cause for the observed differences in flask measurements would not be possible. Both components of quality control are essential. The probable causes of the observed differences between MSC and NOAA may be narrowed to errors introduced during sample collection, storage, extraction, and analysis at either or both laboratories. MSC and NOAA are currently working together to understand the causes of these differences.